Hickory for Veneer and Plywood

by

John F. Lutz

HICKORY TASK FORCE REPORT

NO. 1

In cooperation with
Southeastern Forest Experiment Station,
Forest Service, U.S. Dept. of Agriculture

JUNE 1955

FOREWORD

Hickory (Carya spp.) has earned the reputation of being one of the world's toughest woods. In shock resistance it has no equal. The reputation earned by hickory is based on the performance of high quality material in products requiring a high degree of strength and toughness.

Today, a limited quantity of high-grade hickory is available and its value and scarcity are well recognized by the wood-using industries. There is, however, a large volume of low-grade hickory that was bypassed when loggers cut our hardwood forests, and many land managers are troubled by the increasing amount of growing space occupied by it. Although this low-grade hickory does not possess the quality or properties required in many products, it is a potentially valuable wood for many uses.

A conference of federal, state, university, and industrial representatives was held in Clemson, S. C., in April 1953, and the Hickory Task Force was organized to promote the utilization of hickory. Accomplishment of this objective will be reached through research and publication of known information.

The Southeastern Forest Experiment Station has assumed the responsibility to edit, publish, and distribute reports containing information which will be developed under this program.

Full acknowledgment is due the many cooperating agencies and individuals who are making the project possible. Subject Matter Committee Chairmen are:

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See the inside back
cover for a list of
hickory reports planned.

HICKORY FOR VENEER AND PLYWOOD

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CONTENTS

SUMMARY

At the Forest Products Laboratory 11 hickory, 15 sweet pecan, and 6 bitter pecan logs were rotary-cut and 2 logs of hickory were sliced into veneer. Data are given describing the quality of the test logs, heating of the bolts and flitches for cutting, lathe settings, drying schedules, and veneer yields. Some properties and potential uses of hickory veneer and plywood are discussed.

INTRODUCTION

Hickory and pecan have been cut into veneer on a small scale by a number of plants in the United States. At present most of the hickory being cut into veneer is being used in specialty products. While there are some technical difficulties, the principal factor limiting the general use of hickory as veneer is apparently the supply of logs of veneer quality.

This report does not attempt to estimate the supply of hickory veneer logs. Information on the location and extent of hickory and pecan will be given in another report in this series. This report discusses some technical aspects of selecting and preparing hickory veneer logs, cutting the wood on the lathe and the slicer, veneer drying, plywood fabricating problems, and properties and uses of the veneer and plywood. The data presented here were obtained mainly from Laboratory tests, supplemented by pertinent information from industry.

As used in this report the term hickory refers to shagbark, mockernut, and pignut hickory. The term pecan includes bitter pecan and sweet pecan. The individual species are given only when there are differences within these two general types.

1/ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

THE SELECTION OF HICKORY VENEER LOGS

Hickory is a rather slow-growing tree, while pecan grows rather rapidly. Both are ring porous and normally straight-grained. Hickory has a specific gravity range of 0.50 to 0.70 and is exceptionally high in strength, toughness, hardness, and stiffness. Pecan is not so dense, hard, or tough as hickory, but it equals or exceeds commercial white oak in these properties. The sapwood of both hickory and pecan is white and the heartwood is reddish brown. The white sapwood varies from about 1 to 4 inches in thickness and may make up one-half or more of the usable volume of the logs. Bitter pecan and, to a lesser extent, sweet pecan and the hickories are subject to ring shake. The hickories frequently have checks in log ends.

Bird peck, insect damage, mineral stain, bark pockets, and knots are other defects that may be found in hickory logs (1, 2, 7, 8).[2] Based on the results of Laboratory tests, logs with pronounced ring shake, end checking, bird peck, and insect damage should not be used as veneer logs.

Description of Test Logs

Thirty-four logs of hickory and pecan were tested at the Laboratory. Most of these logs were woods-run. A few of the logs represented the better grades of hickory and could probably be classified as peeler logs. With the exception of the sweet pecan, the test logs were old growth, varying from 115 to 295 years old. The 15 sweet pecan logs were second growth and varied from 32 to 67 years in age.

The three pignut and the three mockernut logs were said to be typical of the hickory grown in the area represented.

The five shagbark hickory logs were selected for veneer cutting and therefore may have been above average in quality.

The two pignut hickory logs used in the slicing tests were selected as the best logs obtained from 6,000 board feet of woods-run logs.

The six bitter pecan logs were selected in the tree for veneer cutting studies. Most of them were not veneer grade logs.

The sweet pecan logs were reported to be of relatively low quality for the species. As a group they appeared rough and knotty. In some cases bird peck and insect damage were noted on the bark and on the ends of the logs. A further description of the test logs is given in table 1.

CARE AND PREPARATION OF LOGS FOR CUTTING

Log Storage

Hickory logs may deteriorate rapidly during storage, particularly during hot weather. Hickory is susceptible to stain, decay, end checking, and insect attack. Deterioration can be kept to a minimum by rapidly processing the logs into dried veneer. Other means of preventing deterioration of the logs are given in reference (6).

2/ Underlined numbers in parentheses refer to literature cited at the end of this paper.

Table 1.--Description of logs tested

Item	Pignut hickory (*C. glabra*)	Mockernut hickory (*C. tomentosa*)	Shagback hickory (*C. ovata*)	Sweet pecan (*C. illinoensis*)	Bitter pecan (*C. aquatica*)	Pignut hickory (*C. glabra*)
Source of logs	Pickens Co., S. C.	Pickens Co., S. C.	Harlan Co., Ky.	Issaguena Co. Miss.	Holmes Co. Miss.	Hardin Co. Ill.
Number of logs	3	3	5	15	6	2
Log length . . . ft.	16	16	8	8 & 16	12	12
Diameters, small end . . . in.	16 - 17	$13\frac{1}{2}$ - 17	$20\frac{1}{2}$ - 29	11 - 19	13 - 20	16 - 18
Rings per inch	11 - 40	10 - 39	10 - 35	2 - 18	8 - 22	5 - 13
Sapwood width	$3\frac{1}{4}$ - $5\frac{1}{4}$	$2\frac{1}{2}$ - $3\frac{1}{2}$	$1\frac{1}{2}$ - 3	2 - 5	$1\frac{1}{2}$ - $2\frac{1}{2}$	$1\frac{1}{2}$ - $2\frac{1}{2}$
Eccentricity of pith . . . in.	7/8 - $1\frac{1}{2}$	3/4 - 1	$\frac{1}{2}$ - $2\frac{1}{2}$	1 - $3\frac{1}{2}$	$\frac{1}{2}$ - $1\frac{1}{2}$	$\frac{1}{2}$ - 1
Condition at start of test	Ring shake in two of three logs. End checking. Few overgrown knots.	One log had hollow butt $5\frac{1}{2}$ inches in diameter. Few overgrown knots. Shake and checks not severe.	Ring shake in all logs. End checking. Surface clear.	Overgrown knots. End checking. One log had hollow butt.	Ring shake. Fire scar. End checking	End splits. Bird peck visible on log ends.
Average moisture content						
Heartwood . . . percent	74	76	73	71	89	56
Sapwood . . . percent	50	53	52	62	104	69
Range of specific gravity	0.60 - 0.70	0.55 - 0.67	0.51 - 0.66	0.53 - 0.63	0.48 - 0.60	0.51 - 0.65
Defects encountered in cutting	Slight breakage due to shake, bark pockets, bird peck, wood-borer damage, mineral deposits, knots.	Slight breakage due to checks, bark pockets, bird peck, wood-borer damage, heavy mineral stain, mineral deposits, knots.	Severe breakage due to shake, bark pockets, bird peck, mineral deposits.	Gelatinous fibers, bird peck, stain, knots, ring shake.	Bird peck, knots, splits, bark pockets, ambrosia beetle galleries.	Bird peck and associated stain.
Veneer cutting method	Rotary	Rotary	Rotary	Rotary	Rotary	Slicing

Bucking Logs into Veneer Bolts and Sawing Them into Flitches

When bucking logs for cutting on the lathe or slicer, the defects in the logs. should be considered. In general, straight logs should be used for long bolts or flitches, while logs with sweep or crook should be cut into shorter bolts or flitches. Whenever possible, overgrown knots and other obvious defects should be cut out when the logs are cut into bolts or flitches.

Experimental results indicate that the best grade of hickory veneer can be obtained by slicing quartered flitches. Logs should be 18 inches or larger in diameter to yield quartered flitches large enough to be economically usable. Splits in the log ends can be minimized by making the saw cut through the largest splits. If possible, small splits should be placed parallel to the slicing face. In this manner losses due to end splits, which are one of the major defects in hickory logs, can be kept to a minimum.

Effect of Heating on End Checking

Ring shakes and splits in unheated bolts were generally enlarged by heating. The higher the conditioning temperature, the greater was the increase in these defects. However, the presence of small splits and ring shakes in the unheated bolts appeared to be more important in the development of these defects than did the temperatures at which they were conditioned. In heating hickory flitches, on the other hand, the enlargement of splits was not a problem. Most of the splits in the unheated logs were eliminated when the flitches were sawn. The splits that were in the flitches did not open significantly during heating.

Recommended Heating Schedules

Veneer was cut from hickory bolts at temperatures varying from 80° to 210° F. In general, the overall quality of the veneer improved with each increase in heating temperature until a temperature of 200° F. was reached. Veneer that was rotary cut at 210° F. was somewhat fuzzy, probably because of overheating. Veneer sliced from flitches at 200° F. did not have fuzzy surfaces.

It was extremely difficult to peel the bark from bolts at room temperature. Heating the bolts at 170° F. or higher facilitated the removal of the bark.

As a result of the above tests it is suggested that hickory bolts be heated in water at 170° F. Large bolts take longer to heat than small ones. The approximate time that would be required for conditioning 8-foot hickory bolts in water at 170° F. to insure a temperature of 150° F. at the perimeter of an 8-inch core is as follows:

Bolt Diameter (Inches)	Heating Time (Hours)
12	11
18	29
24	62
30	110

Since end splitting as a result of heating is not a problem with flitches, they could be heated in water at temperatures of 190° or 200° F. Hickory flitches that are not over 8 inches thick can be heated in 24 hours. Flitches much larger than this should be heated for 2 days.

VENEER CUTTING

Laboratory tests and reports from industry indicate that smooth, tight veneer can be cut from heated bolts and flitches. The lathe settings given in table 2 were satisfactory for rotary cutting 1/32, 1/16, 1/8, and 1/6-inch veneer (4).

Table 2.--Lathe settings used for rotary cutting hickory veneer

Veneer thickness	Knife angle	Pressure-bar opening	
		Horizontal	Vertical
Inch	Degrees and minutes	Inch	Inch
1/32	90-40	0.025	0.012
1/16	90-10	.055	.016
1/8	89-40	.115	.028
1/6	89-35	.150	.030

Hickory veneer was sliced in thicknesses from 1/28 to 1/8 inch in thickness. Satisfactory sliced veneer was obtained by using a knife angle of 90^{o}-20', a bar height of 0.035 inch, and a bar opening of 0.006 to 0.007 inch less than the thickness of the veneer being cut. In general, veneer sliced from quartered flitches was smoother and tighter than rotary-cut veneer of the same thickness.

Effect of Grain Orientation on Slicing

The following technique was used to produce the best cut quartered veneer. The flitches were mounted on the flitch table so that the slicing cut was always from the heartwood to the sapwood. Veneer was cut from the flitch until the true quarter surface was reached. Then the flitch was reversed and the quartered surface was placed against the flitch table. The remainder of the flitch was then sliced into veneer. If the flitch was not reversed when the true quarter was reached, the veneer sliced from the last half of the flitch was rough.

Effect of Log Defects

Overgrown tracings of cambium mining insects and bird pecks were numerous in the test logs. Mineral deposits associated with these defects frequently nicked the lathe knife. Furniture manufacturers have also reported that the abrasive character of pecan required the use of special cutting tools (5). Mineral deposits did not nick the slicer knife as much as they did the lathe knife. Ring shake caused considerable loss at the lathe during cutting, especially in the bitter pecan and the shagbark hickory logs. Other defects that caused degrade of the veneer were mineral stain, knots, bark pockets, and splits.

VENEER DRYING

As shown in table 1, there was considerable range in the moisture content of the sapwood and heartwood of the various species studied. In addition, there was a considerable range in the moisture content of various logs of the same species. Bitter pecan had the highest moisture content and required the longest drying time of all the species studied. It required about 25 percent more drying time than sweet pecan and the hickories. In all cases the heartwood took slightly longer to dry than the sapwood of the same species, even when the moisture content of the heartwood was less than that of the sapwood. Time for drying heartwood was about 10 percent longer in pecans and the pignut hickory, and 25 percent in the other hickories.

Most of the veneer was dried satisfactorily in a roller conveyor dryer at temperatures of 250^{o} and 315^{o} F. Approximate drying schedules for the sapwood veneer of sweet pecan and the hickories are given in table 3.

Drying times given in table 3 should be increased 10 to 25 percent for the sapwood of bitter pecan and the heartwood of all the species studied. The times listed are only approximate because veneer from different bolts varied considerably in drying time.

Some of the 1/16-inch and thinner veneer had a slight buckle between the springwood and summerwood after drying. Veneer from quarter-sliced flitches tended to bow slightly toward the sapwood during drying. Neither of these drying defects was serious enough to be a limiting factor in using hickory as veneer.

Table 3.--Approximate drying schedule for sapwood veneer of hickory and sweet pecan

Veneer thickness	Temperature in dryer	Time in dryer	Final moisture content
Inch	°F	Minutes	Percent
1/32	250	5	2 to 4
1/28	250	6	2 to 4
1/16	250	10	2 to 4
1/16	315	6	2 to 4
1/8	250	24	2 to 4
1/8	315	12	2 to 4
1/6	315	14	9 to 13

Tangential shrinkage during drying of rotary-cut hickory veneer to a moisture content of 2 to 4 percent was about 10 percent of the green width. Shrinkage for pecan was 8.5 to 9 percent. Quarter-sliced hickory shrank 6 to 7 percent of its green width.

VENEER YIELDS

In the Laboratory studies, yields of dry veneer in sheets 6 inches and wider were measured for all the rotary-cut veneer. When compared with the net log scale Scribner Decimal C, these yields showed overrun of 8.0 percent for the sweet pecan, 0.6 percent for the bitter pecan, and 3.3 percent for hickory. When compared with the Doyle rule, the overrun figures were 18.0 percent for sweet pecan, 7.9 percent for bitter pecan, and 9.0 percent for hickory. Yield figures obtained in Laboratory tests may be considerably higher than those attainable under commercial conditions.

VENEER GRADES

Veneer obtained from the rotary-cut bitter pecan and hickory test logs was graded according to Commercial Standard CS 35-49 (3). Because of the low quality of the sweet pecan logs, little standard grade veneer was produced from this species. CS 35-49 does not describe a No. 1 grade for hickory or pecan veneer. It does list pecan as a "high density" species along with such species as red and white oak. The rule for grade 1 red and white oak veneer was therefore used in applying the grading rules for the test veneer. On this basis, the percent of veneer in various grades for the four species was as follows:

Species	Number of logs	Grade 1 (Percent)	Grade 2 (Percent)	Grade 3 (Percent)	Grade 4 (Percent)
Pignut hickory	3	28	24	14	34
Mockernut hickory	3	18	15	15	52
Shagbark hickory	5	44	12	22	22
Bitter pecan	6	26	19	28	27

A considerable amount of this veneer was in narrow widths. When the same veneer was graded with the requirement that all grade 1 and 2 veneer sheets should be at least 2 feet wide, the yield by grade was changed as follows:

Species	Number of logs	Grade 1 (Percent)	Grade 2 (Percent)	Grade 3 (Percent)	Grade 4 (Percent)
Pignut hickory	3	5	10	53	32
Mockernut hickory	3	--	3	48	49
Shagbark hickory	5	1	6	69	24
Bitter pecan	6	9	8	50	33

There was considerable variability between individual logs in the grade-yield of veneer. For example, one rotary-cut bitter pecan log graded with 24 inches as the minimum width yielded 41 percent grade 1, 17 percent grade 2, 31 percent grade 3, and 11 percent grade 4. Another example of high grade yield was the sliced veneer obtained from the two pignut hickory logs. Thirty percent of this veneer was grade 1, 41 percent was grade 2, 12 percent was grade 3, and 17 percent was grade 4.

Container Veneer Grades and Yields

As reported earlier, the sweet pecan logs used in this study were of low quality. The veneer obtained from these logs was graded for possible use as box shook, into two classes: usable or non-usable.

In the absence of any standard grading rules for box shook, the grading was done on the basis of whether ends of the shook were strong, sound, and free of knots that might interfere with nailing and whether any open defect in the shook was bad enough to injure the contents of the box. This last rule prohibited practically all open defects, particularly those with sharp edges that might cut into the contents of the box. The shook size chosen for grading was 5 by 26 inches, a typical size of shook used in a wirebound box.

The total yield of dry sweet pecan veneer was 118 percent of the Doyle lumber scale of the logs. Eighty-one percent of this yield was graded as acceptable box shook and 19 percent was reject box shook.

COLOR AND FIGURE OF HICKORY VENEER

Hickory and pecan have white sapwood and reddish-brown heartwood. In the faster-grown trees, the sapwood may make up 50 percent or more of the usable volume. Contrast in color between the sapwood and heartwood is considered by some cabinet makers to be a disadvantage. They prefer a solid dark or a solid light color. If the veneer is rotary cut, most of the white sapwood can be separated from the dark heartwood. Manufacturers then could supply white or brown-faced panels. Examples of white and brown-faced panels are shown in figures 1 and 2. Sliced veneer will generally contain mixed white sapwood and brown heartwood. Such veneer can be used to make a pattern as shown in figure 3.

Hickory is subject to dark mineral streaks. These streaks are apparently caused by injury to the cambium by bird pecks or insects. The streaks make a marked contrast with the light brown heartwood as well as with the white sapwood (fig. 3). Since these streaks are common, perhaps the best way to market them would be to consider them as character marks rather than as defects. One commercial plant reported that they had successfully sold hickory panels using this marketing approach.

The fine rays in hickory add to the figure of the wood when the veneer is sliced on a true quarter (fig. 3).

HICKORY PLYWOOD

Hickory plywood can be manufactured by methods commonly used with other hardwood species. In Laboratory tests, satisfactory initial dry bond strength was obtained with cold-press casein glue. When the plywood was hot pressed with a 50 percent extended urea glue, the glue bond passed the delamination test for interior plywood specified by CS 35-49. Satisfactory exterior-type glue joints, as specified by CS 35-49, were made with a liquid phenolic glue. Pressures of 250 to 275 pounds per square inch were used when making hickory plywood. Because of the density and high compressive strength of hickory, a pressure as high as 300 pounds per square inch could probably be used, particularly for cold pressing (9).

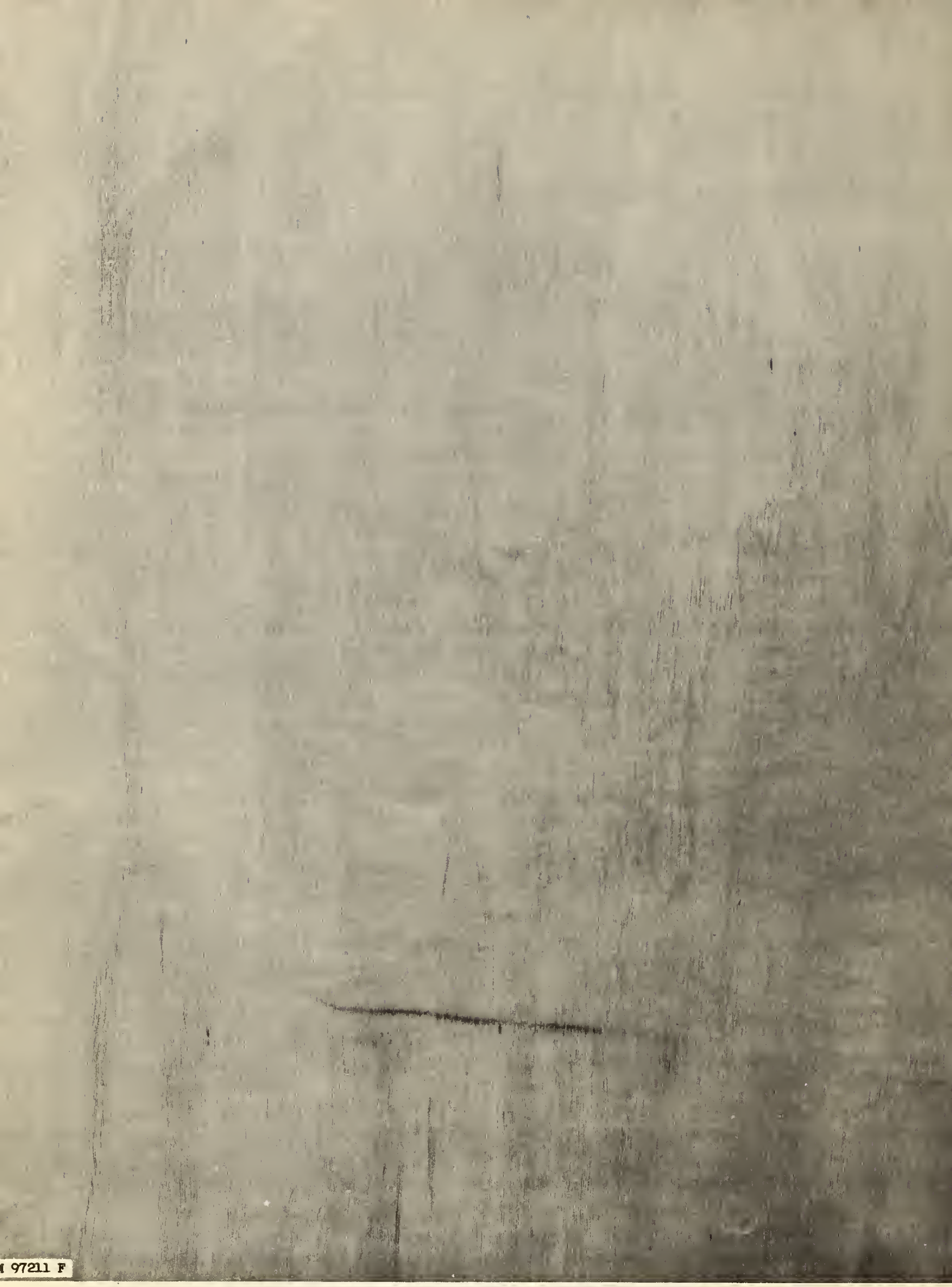

Figure 1.--Blond panel made from sapwood of rotary-cut bitter pecan. The dark line is a mineral streak caused by insect damage.

Figure 2.--Brown-faced panel made from rotary-cut veneer of shagbark hickory heartwood.

Figure 3.--This panel is faced with quarter-sliced pignut hickory. The two light-colored areas are sapwood. The thin dark lines are mineral streaks.

Hickory has high tangential shrinkage. This characteristic may result in some face checking and warping of plywood panels. Precautions may, therefore, be necessary to keep these defects to a minimum. Two factors that should be closely controlled are: (1) moisture content in the veneers prior to gluing so that the moisture added by the glue will bring the panel to the same moisture content that it will attain in use, and (2) balanced construction with respect to grain direction and thickness of opposing plies.

PLYWOOD EXPOSURE TESTS

Three-ply and 5-ply hickory and pecan plywood having rotary-cut veneer faces 1/16 inch and 1/8 inch thick were given interior and exterior exposure tests at the Laboratory. The interior exposures consisted of placing panels alternately into high-humidity and low-humidity atmospheres for a period of 1 month at each condition, so that the moisture content varied alternately from about 6 percent to 15 percent or from 6 percent to 20 percent. These changes are probably more severe than plywood would experience in general indoor use.

After 2 cycles of interior exposure to high and low humidity, the hickory and pecan panels with 1/8-inch face veneers showed slight face checking and grain raising. Warping was severe on most of these panels. The 3-ply panels warped more than the 5-ply panels. Later tests showed that the warp was reduced by about 1/3 when spruce rather than pecan was used for the inner plies. The same effect could probably be obtained by using inner plies of other low-density, straight-grained woods.

Exterior type panels were exposed outdoors on a test fence facing south. Face checking developed on unpainted panels after 2 weeks' exposure. Painted panels had slight to moderate face checking after 1 year of exposure. Panels with veneer faces 1/8-inch thick developed larger checks sooner than panels with 1/16-inch thick faces.

USES

Commercial Experience

Some high-grade veneers of sweet pecan are used for wall paneling and parquet flooring. Hickory veneer has also been used for school furniture. During World War II hickory veneer was used to make laminated skis for moving military equipment in the Arctic.

Lower grades of hickory are used for industrial fiber brooms and for boxes and crates. Tobacco hogsheads and other bent wooden containers have been made of hickory veneer.

Indicated in Laboratory Tests

Results of this study indicate that veneer from the better hickory and pecan logs could be used for faces of furniture plywood and paneling. The hardness and toughness of the wood make it suitable for flooring. An experimental flexible 2-ply floor with hickory veneer faces laid in cold mastic on a concrete base is in excellent condition after 3 years' use.

The lower grade hickory veneer can probably best be used in boxes and crates. Because of the tough pliable character of green hickory veneer, it should be particularly useful as a substitute for elm and other species now used in the manufacture of bent wood basket parts.

(1) Betts, H. S.
1945. American woods--hickory. Forest Service, U. S. Dept. Agr. 10 pp.

(2) ______________
1945. American woods--pecan. Forest Service, U. S. Dept. Agr. 9 pp.

(3) Bureau of Standards
1945. Commercial standard CS 35-49 hardwood plywood. U. S. Dept. Comm. 27 pp.

(4) Fleischer, H. O.
1949. Experiments in rotary veneer cutting. Proc. Forest Products Research Soc. 3:137-155.

(5) Murphy, S. J.
1938. Louisiana sweet pecan, the stubborn aristocrat of furniture woods. Furniture Manufacturer 53(9): 12-13, 26-27.

(6) Southern Forest Experiment Station
1949. Prevention of deterioration in stored southern hardwood logs. 6 pp. (Mimeo.)

(7) Southern Hardwood Producers, Inc.
1940. Southern hardwoods, No. 3, hickory. Southern Lumberman 161(2030): 27.

(8) ______________
1940. Southern hardwoods, No. 4, pecan. Southern Lumberman 161(2031): 27.

(9) Truax, T. R.
1929. The gluing of wood. U. S. Dept. Agr. Bul. No. 1500. 77 pp.

Agriculture-Asheville

HICKORY REPORTS PLANNED

Location and extent of hickories.
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Hickory for veneer and plywood.*
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